Management of AKI

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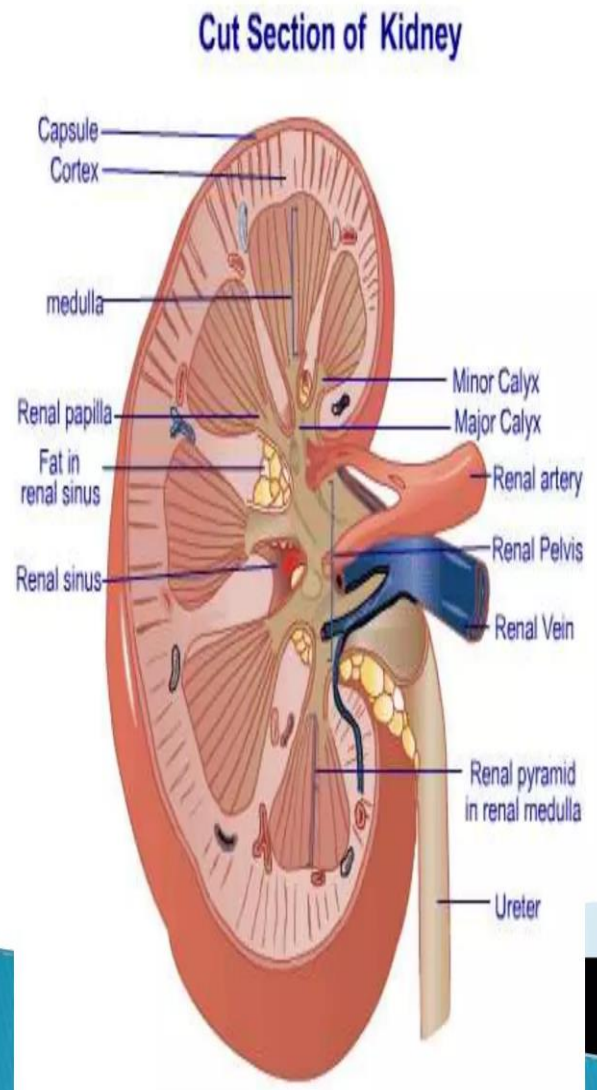
Objectives

- Epidemiology.
- What is AKI.
- Diagnosis &D.D.
- Management.
- Take home massage.

ACUTE RENAL FAILURE



Epidemiology

- 0.7%-31%.
- In ICU up to 50%.
- Mortality up to 23%.
- Post cardiac and vascular Surgery 11-30% (2% required RRT).
- 7% of hospital admission and 30% of ICU admission.(Goyal et al.2023)
- 3-5% of AKI end with long term RRT.

Do not forget

- ***Anuria*** (< 100 mL/day) - Urinary tract obstruction, renal artery obstruction, rapidly progressive glomerulonephritis, bilateral diffuse renal cortical necrosis
- ***Oliguria*** (100-400 mL/day) - **Prerenal failure, hepatorenal syndrome, and AKI**
- ***Non-oliguria*** (> 400 mL/day) - Acute interstitial nephritis, acute glomerulonephritis, partial obstructive nephropathy, nephrotoxic and ischemic acute tubular necrosis, radio contrast-induced AKI, and rahabdomyolysis.
- ***Polyuria*** (> 3000ml/day) D.I ,uncontrolled DM,psychogenic,diueretics,RF.
- Creatinine remains normal up to GFR of **50%**

What is AKI

- **Definition:** There is no clear definition , however , several different criteria have been used. Among these **KDIGO** reported any :

1. Increase creatinine by **0.3mg/dl** within 48 hours.
2. Increase creatinine **1.5 times** within one week.
3. Urine output less than **0.5 ml/kg/h for more than 6 hours**.

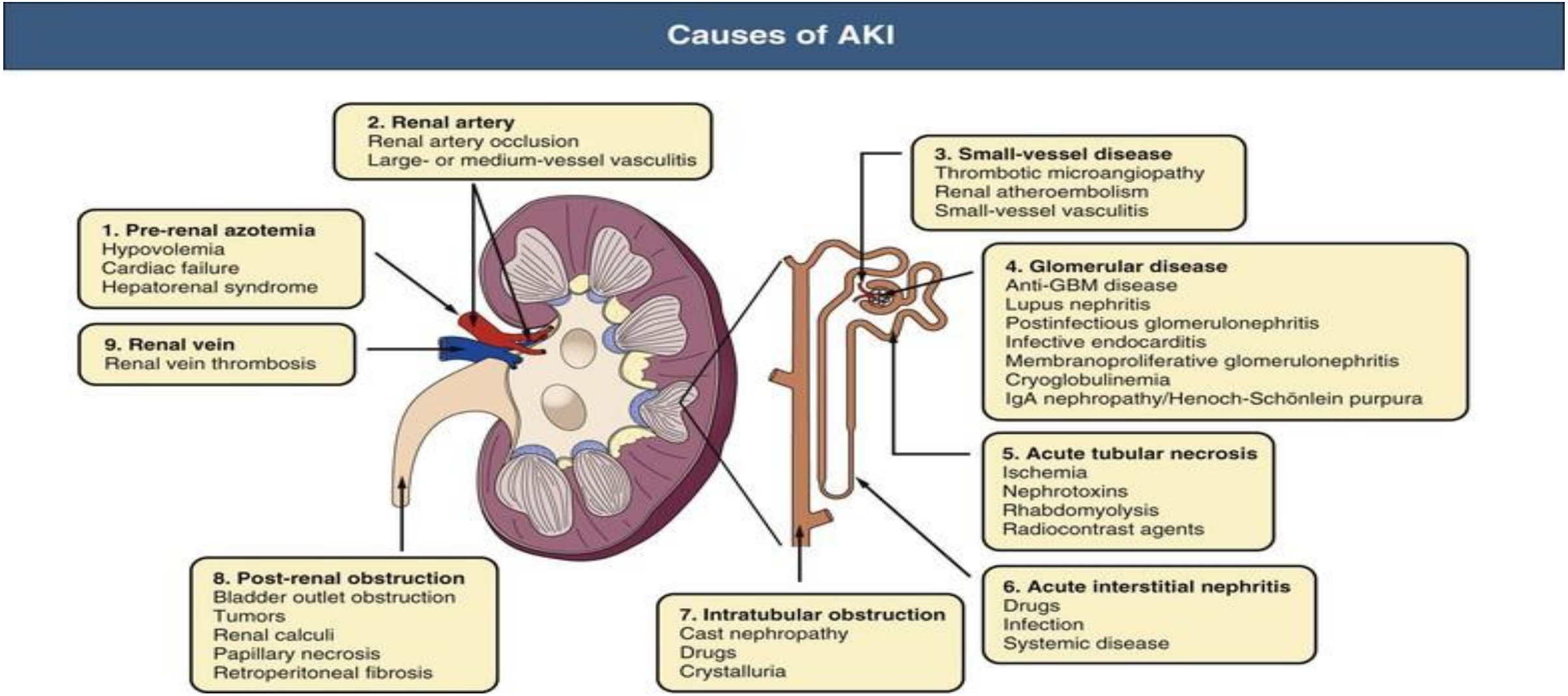
- **Pathophysiology:**

1. Prerenal.

2. Renal.

3. Postrenal.

Pathophysiology of AKI



Stages of AKI

ACUTE KIDNEY INJURY

	CREATININE AND/OR	URINE OUTPUT
STAGE 1	Rise 1.5-2 fold from baseline	≤0.5 ml/kg/hr more than 6 hours
STAGE 2	Rise of 2-3 fold	≤0.5 ml/kg/hr more than 12 hours
STAGE 3	Rise >3 fold	≤0.3ml/kg/hr more than 24 hours

CAUSES: THINK SHTOP

S epsis
H ypovolaemia
T oxicity
O bstruction
P arenchymal disease

ASSESS:

- Fluid balance
  - BP
  - Urine output
- Examine chest and bladder

INVESTIGATIONS

- Routine blood test, ABG/VBG
- Urine dip
- Arrange US if suspected obstruction or not responding to fluids

MANAGEMENT

- IV Fluids: Aim BP>100 systolic and urine output>0.5ml/kg/min
- Consider sepsis and treat accordingly
- Stop antihypertensives if hypotensive
- Stop nephrotoxins (e.g. ACEIs, ARBs, NSAIDs), diuretics and metformin
- Avoid contrast if possible
- Discuss with Renal Team if stage 3 (any stage if urine dip +ve)

D.D.

- Abdominal aneurysm.
- Dehydration.
- Diabetic ketoacidosis.
- Gastrointestinal (GI) bleeding.
- Heart failure &Metabolic acidosis.
- Protein overloading.
- Sickle cell anemia.
- Steroid use.
- Urinary obstruction &Urinary tract infection.

Last decade proved inadequacy of Definition

a.The rise in SCr is often delayed **48–72 h** after kidney injury. Moreover, SCr is influenced by several factors affecting its production (**age, gender,diet, muscle mass, sepsis**,**fluid administration, elimination** and secretion (**medications**).

b. Accordingly, in the surgical setting, **muscle wasting and positive fluid balance** are associated with lower SCr and lead to the underestimation of AKI.

C.UO is an early marker for AKI, independent of SCr, but It is influenced by the use of **diuretics**, difficult to assess without a **urinary catheter**. The physiological response to surgery by reducing UO **(ADH)** limits its use.

Diagnosis

a.AKI has identified plasma and urine neutrophil gelatinase-associated lipocalin (**NGAL**), **urine IL-18** and **albuminuria** as the most promising postoperative markers.

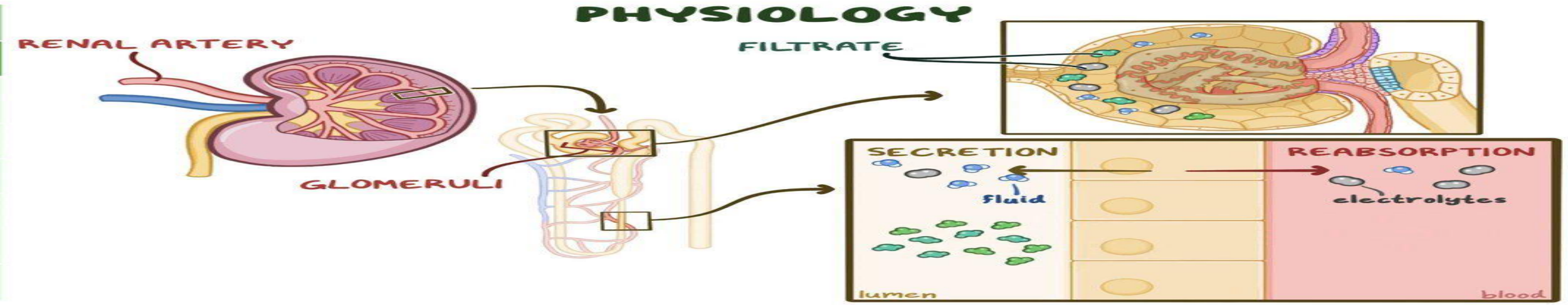
b.The most recent AKI markers are tissue inhibitor of metalloproteinases-2 **(TIMP-2)** and insulin-like growth factor binding protein 7 **(IGFBP7)** .

C.Other promising biomarkers have also been studied,namely kidney injury molecule 1 **(KIM-1**), interleukin 18 (IL-18), liver-type fatty acid-binding protein (**L-FABP**), N-acetyl-glucosaminidase (**NAG**), monocyte chemoattractant protein 1 (**MCP-1**).

d.Urine angiotensinogen (**AGT**), and **urine vanin-1**, **urine microRNAs**.

PreRenal AKI(55%)

- ***Hypovolemia***: Hge , burn , GIT loses.
- ***Hypotension***: decreased COP, cardiogenic shock , massive PE,ACS.
- ***Extensive systemic VD***: septic shock, anaphylaxis, anesthesia ,Cirrhosis.
- ***Renal VC***: NSAIDS, Contrast, amphotercine B, Calcineurin inhibitors.
- ***Glomerular efferent arteriolar vasodilatation***: ACEI , ARBs



Renal AKI(45%)

- **Acute tubular necrosis (45%):**

Prolonged ischemia, aminoglycosides,vancomycin,rhabdomyolysis,hemolysis.

- **Acute interstitial nephritis(2%) :**

autoimmune, NSAIDS,PPIs,beta lactam.

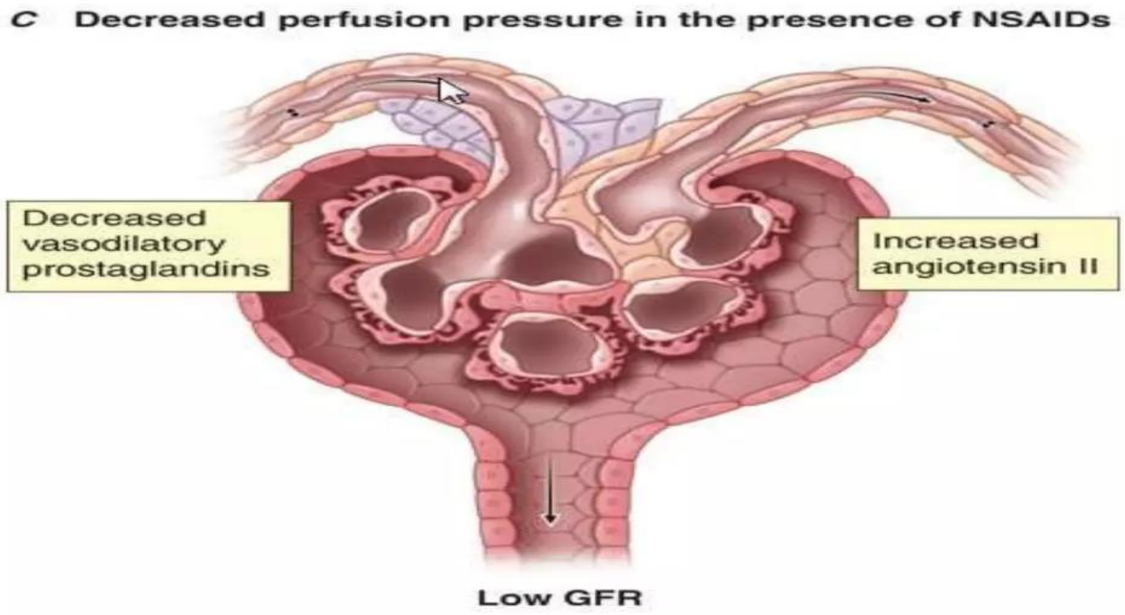
- **Glomerulonephritis(24%):**

Infections, autoimmune , vasculopathy..

- **Intratubular Obstuction(29%):**

Multiple myleloma,tumour lysis,toxins .

GFR


C Decreased perfusion pressure in the presence of NSAIDs
Decreased vasodilatory prostaglandins
Increased angiotensin II
Low GFR

Urine in Intra-renal AKI

urinalysis in AKI

Diagnosis	Urinalysis	Microscopy	Diagnostic clues beyond UA
Glomerulonephritis	- Hematuria - Proteinuria (can be >2-3g/d)	- RBC casts - Dysmorphic RBCs	- Associated with numerous diseases (e.g. ANCA vasculitis, SLE, infection). - Urine can be bloody or tea-colored.
Acute interstitial nephritis (AIN)	- WBCs without bacteria - Hematuria - Proteinuria (mild, <2-3g/d)	- WBC casts	- Fever - Rash - Blood eosinophilia - Causative drug (often NSAIDs, ABX)
Pyelonephritis	- WBCs - Bacteria, Nitrites	- WBC casts	- Fever - Lower urinary tract symptoms - Flank pain
Acute Tubular Necrosis (ATN)		- Muddy-brown casts	
Rhabdomyolysis Hemolysis	- Positive hemoglobin *without* RBCs		- Rhabdomyolysis: CK elevation - Hemolysis: ↑LDH, ↓ hemoglobin,

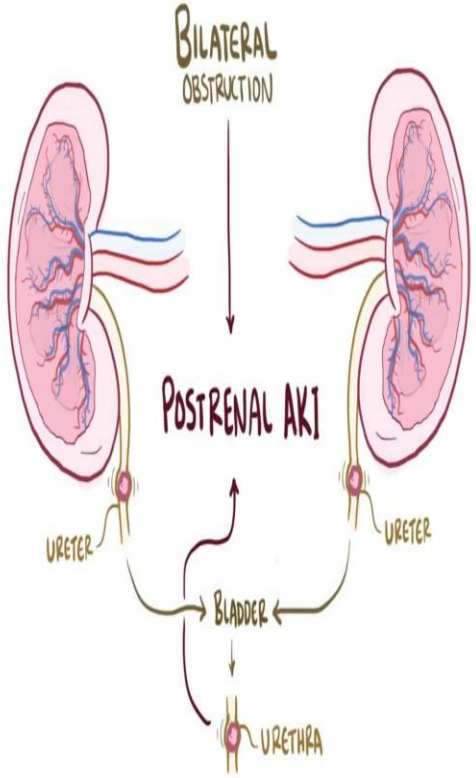
Post Renal AKI(5%)

- **Obstruction**

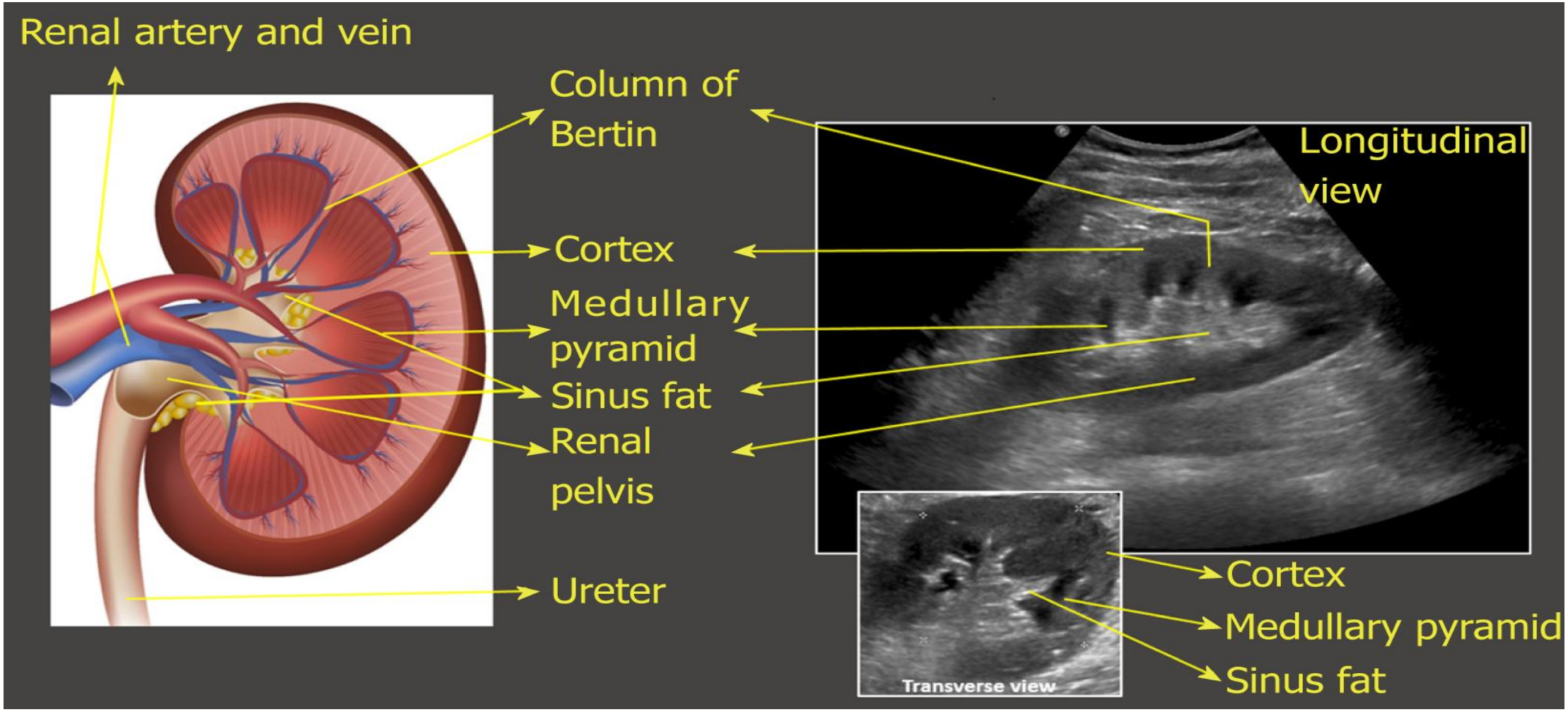
-The most common are **stones, tumors, blood clots, huge prostate** .

-It is supposed that contralateral kidney can compensate .

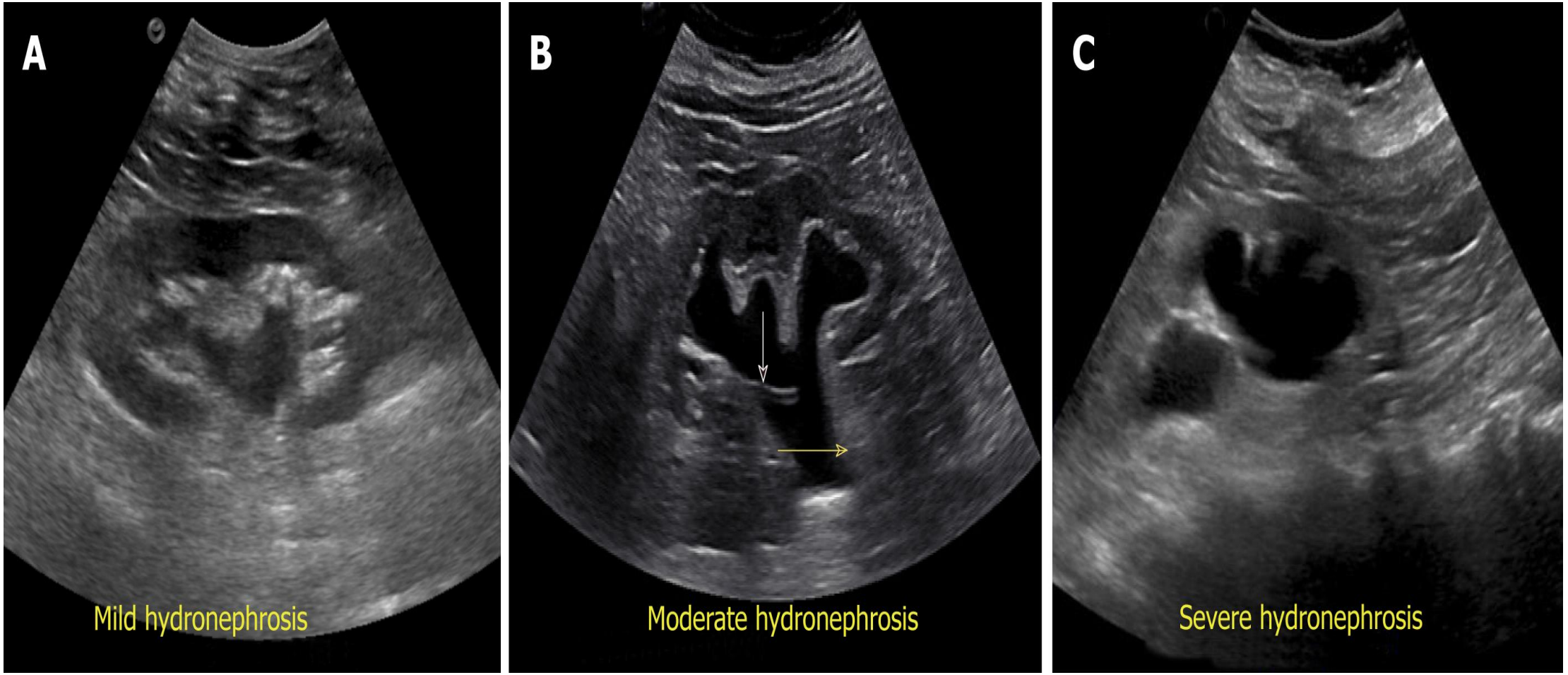
-**Obstruction of urinary catheter** should be considered.



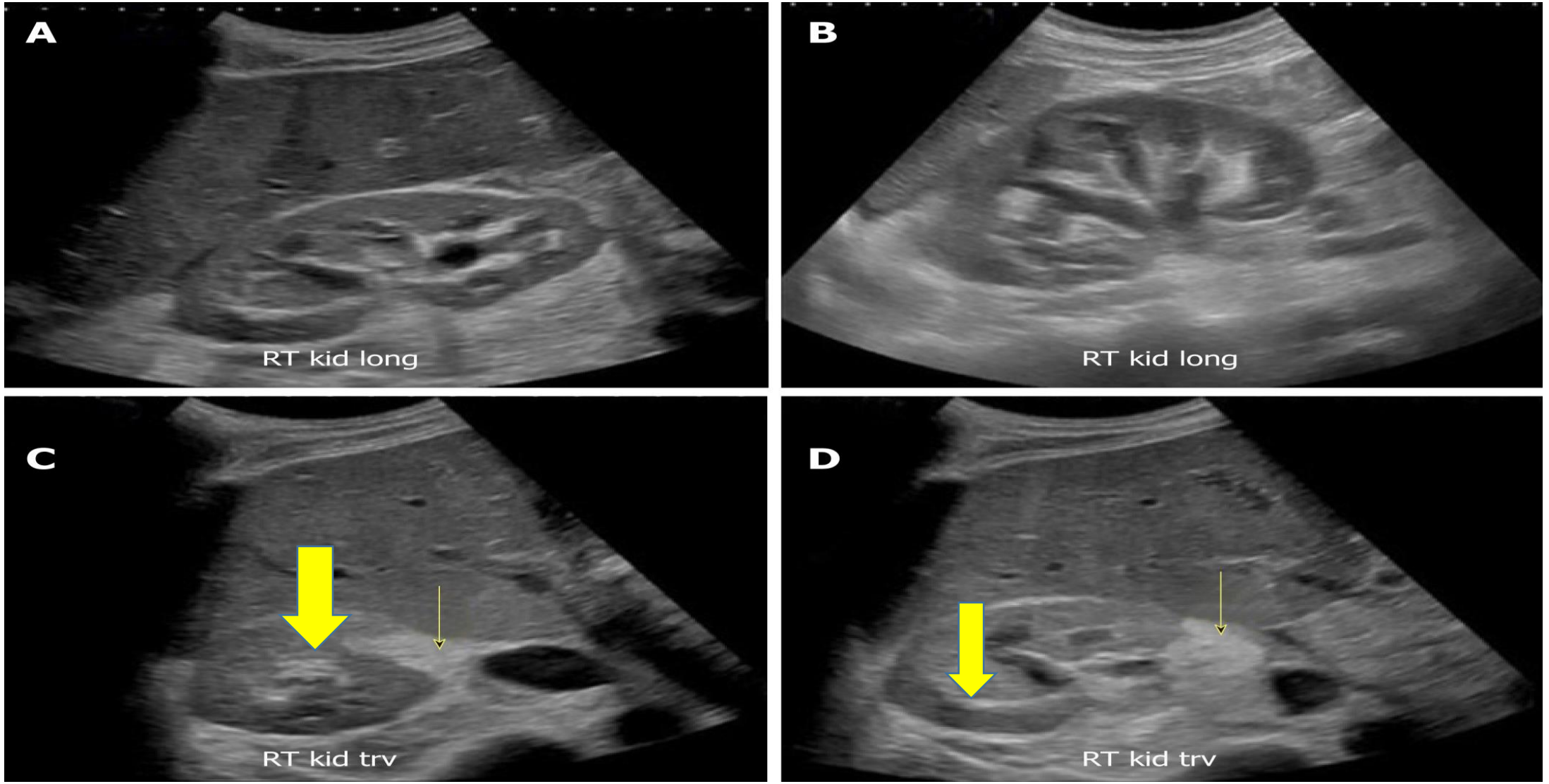
POCUS in AKI


Renal artery and vein
Column of Bertin
Cortex
Medullary pyramid
Sinus fat
Renal pelvis
Ureter
Longitudinal view
Transverse view
Cortex
Medullary pyramid
Sinus fat

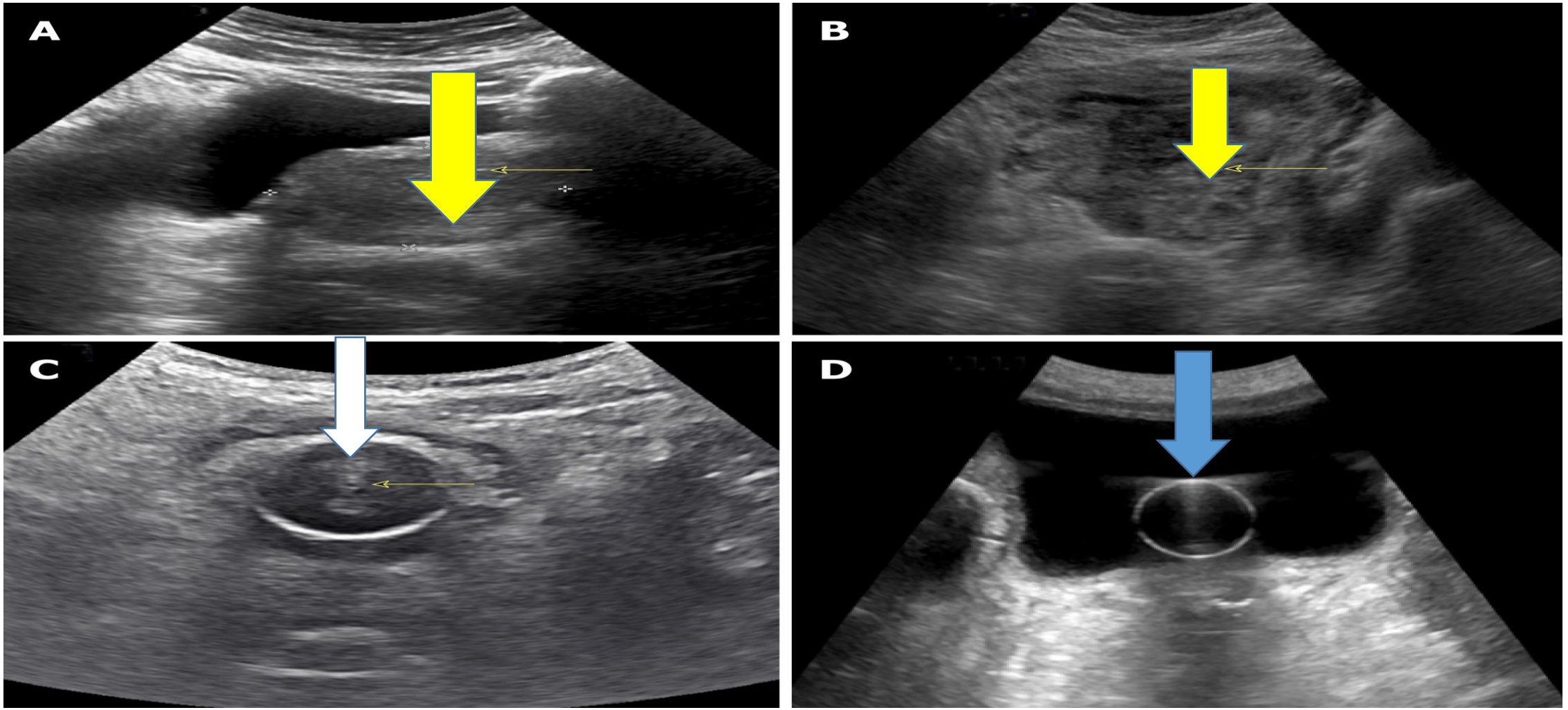
POCUS in AKI


A
Mild hydronephrosis
B
Moderate hydronephrosis
C
Severe hydronephrosis

POCU in AKI



POCUS of UB



Management

- ***Order:***

1. Complete blood count (CBC).
2. Serum biochemistries.
3. Urine analysis with microscopy , Fractional Excretion of Sodium and Urea.
4. Urine electrolytes.
5. ABG or VBG.
6. Renal imaging e.g. US ± Doppler trace , angio.
7. FST 1mg furosemide/kg ➡ less than200ml in 2 hours of bad prognosis

Management

- Therapeutic agents (eg, **dopamine, nesiritide, fenoldopam, mannitol**) are **not** indicated in the management of AKI and may be harmful.
- Maintenance of **volume homeostasis(TFB)** and correction of **biochemical abnormalities.**
- include the following measures:

*-Correction of fluid overload with **furosemide***

*-Correction of severe acidosis with **bicarbonate** administration.*

*-Correction of **hyperkalemia***

*-Correction of **hematologic** abnormalities (eg, anemia, uremic platelet dysfunction)*

*- Albumin-Colloid are **reno-protective** ??? while starch is nephrotoxic.*

Management

- **Restriction of salt and fluid** becomes crucial in the management of oliguric kidney failure.

- **Potassium and phosphorus** are not excreted optimally in patients with AKI. Restriction of these elements in the diet may be necessary, In the **polyuric** phase of AKI, potassium and phosphorus may be depleted.

RRT

- ***Indications of RRT:***

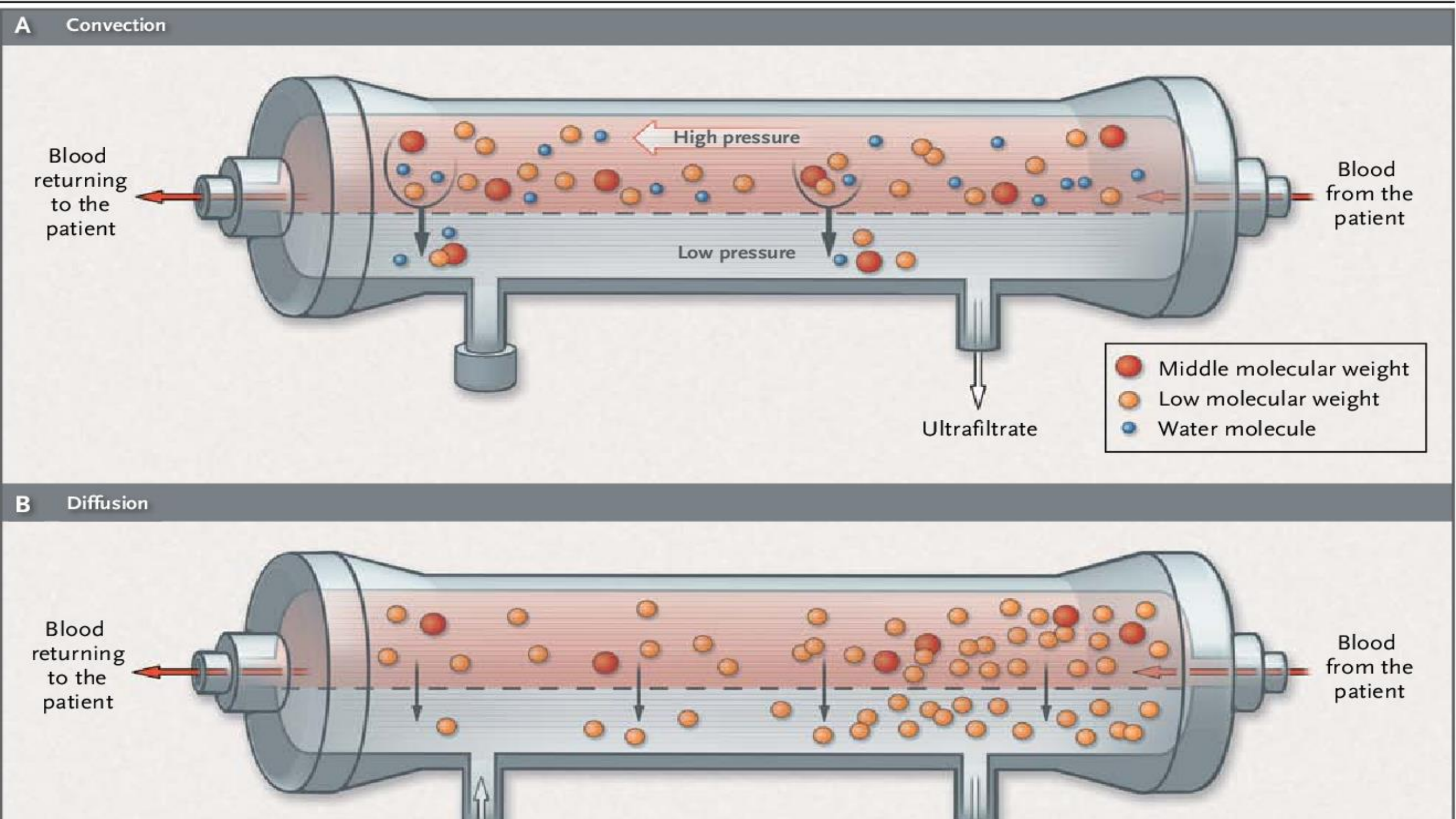
❑*Severe/refractory hyperkalemia*

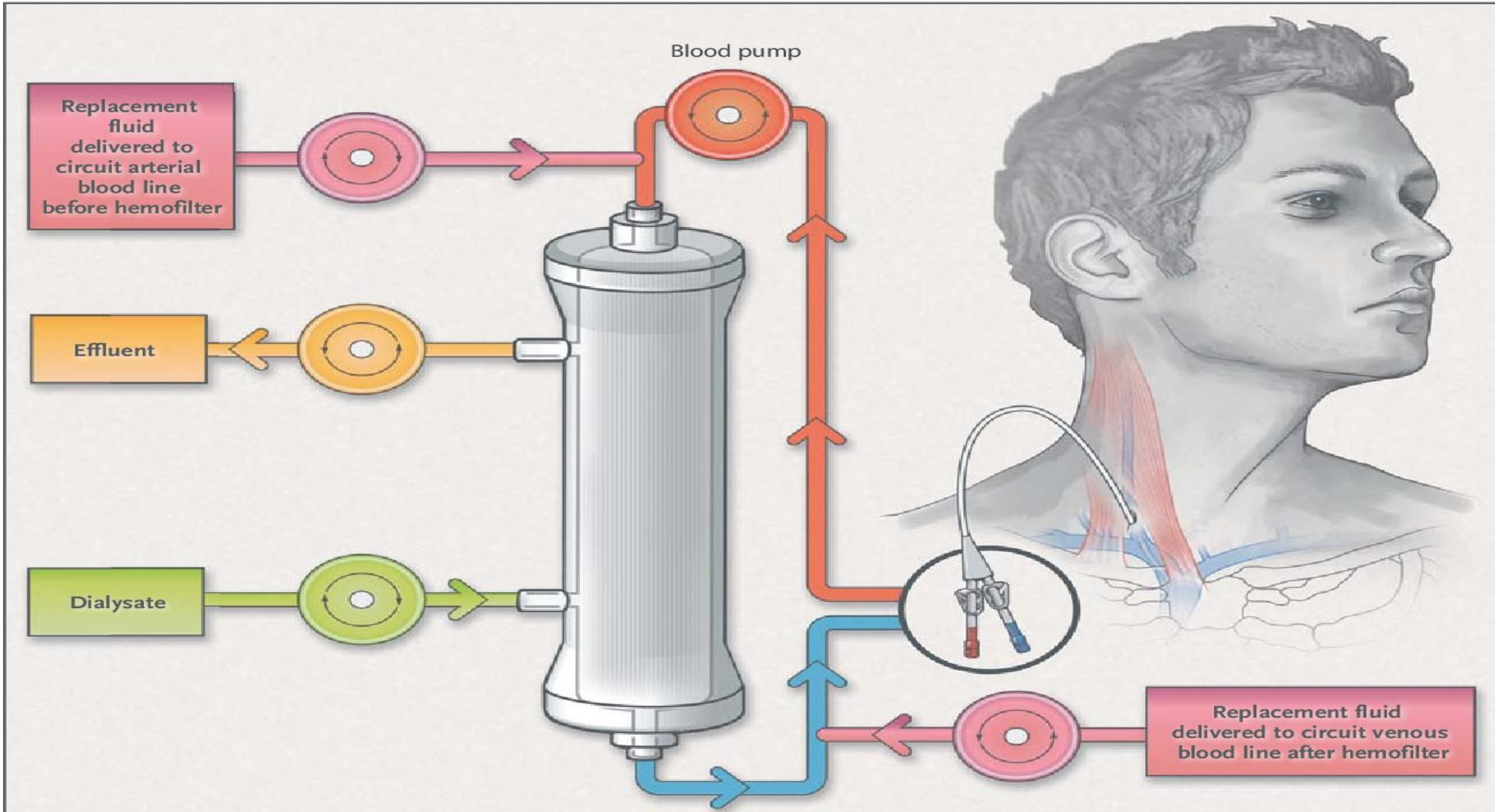
❑*Severe/refractory metabolic acidosis*

❑*Refractory volume overload*

❑*Clinical complications of uremia (encephalopathy, pericarditis or neuropathy)*

❑*Consider early RRT start*


A Convection
Blood returning to the patient
High pressure
Low pressure
Blood from the patient
Ultrafiltrate
Middle molecular weight
Low molecular weight
Water molecule
B Diffusion
Blood returning to the patient
Blood from the patient


Blood pump
Replacement fluid delivered to circuit arterial blood line before hemofilter
Effluent
Dialysate
Replacement fluid delivered to circuit venous blood line after hemofilter

Prevention of Contrast-Induced Nephropathy

- **Saline**

Normal saline and isotonic sodium bicarbonate have proved to be **effective.** A normal saline solution of **1 mL/kg/h administered 6-12 hours before the procedure and then 6-12 hours after.**

- **N-acetylcysteine**

Oral ***N-acetylcysteine at a dosage of 1200 mg every 12 hours***. More recent data from a large randomized trial did **not** demonstrate a reduction in AKI incidence using N-acetylcysteine.

- **Statins**

A meta-analysis found that ***statin treatment before coronary angiography*** can **reduce** contrast-induced AKI.

- **Forced diuresis**

Mannitol **is in fact detrimental** for contrast-induced nephropathy.

-**The RenalGuard System** (RenalGuard Solutions, Inc; Milford, MA), that matches saline infusion rates to the patient's urine output by volume and time. The device is commercially available in Europe but is still under study in the United States.

Management

- Renal recovery in most cases is not complete.
- Renal recovery is usually observed within the **first 2 weeks**, and many nephrologists consider **irreversible kidney failure 6-8 weeks** after the onset of AKI.
- It is always better to check these patients **periodically.**

AKI in Liver cirrhosis(HRS)

- ***Best Practice Advise(2022)***

(1) avoidance of potentially nephrotoxic medications.

(2) avoid excessive or unmonitored diuretics or nonselective beta-blockade.

(3) avoidance of large-volume paracentesis without albumin replacement.

(4) counseling patients to avoid red protein.

AKI in Liver cirrhosis

- When the serum creatinine remains **higher than twice**, treatment of HRS-AKI should be initiated with ***albumin at a dose of 1 g/kg intravenously on day 1 followed by 20–40 g daily .***

- if **Terlipressin** is not available, either a ***combination of octreotide and midodrine; or norepinephrine*** continued either until 24 hours following the return of the serum creatinine level to within 0.3 mg/dL of baseline for 2 consecutive days or for a total of 14 days of therapy.

Cardio-Renal AKI

- ❑Early inotropic support.
- ❑Minimize preload and afterload.
- ❑Measures to prevent or control arrhythmia.
- ❑Mechanical inotropic support as IOP.
- ❑ECMO has a role in ischemic insult.
- ❑Apply recent guidelines in HF.

Algorithm 1: Assessment

Using an ABCDE (Airway, Breathing, Circulation, Disability, Exposure) approach, assess whether the patient is hypovolaemic and needs fluid resuscitation
Assess volume status taking into account clinical examination, trends and context. Indicators that a patient may need fluid resuscitation include: systolic BP <100mmHg; heart rate >90bpm; capillary refill >2s or peripheries cold to touch; respiratory rate >20 breaths per min; NEWS ≥5; 45° passive leg raising suggests fluid responsiveness.

Yes

Algorithm 2: Fluid Resuscitation

Initiate treatment
- Identify cause of deficit and respond.
- Give a fluid bolus of 500 ml of crystalloid (containing sodium in the range of 130–154 mmol/l) over 15 minutes.

Reassess the patient using the ABCDE approach
Does the patient still need fluid resuscitation? Seek expert help if unsure

Yes

No

Does the patient have signs of shock?

Yes

No

Seek expert help

>2000 ml given?

Yes

No

Give a further fluid bolus of 250–500 ml of crystalloid

No

Assess the patient's likely fluid and electrolyte needs
- History: previous limited intake, thirst, abnormal losses, comorbidities.
- Clinical examination: pulse, BP, capillary refill, JVP, oedema (peripheral/pulmonary), postural hypotension.
- Clinical monitoring: NEWS, fluid balance charts, weight.
- Laboratory assessments: FBC, urea, creatinine and electrolytes.

Can the patient meet their fluid and/or electrolyte needs orally or enterally?

Yes

Ensure nutrition and fluid needs are met
Also see Nutrition support in adults (NICE clinical guideline 32).

No

Does the patient have complex fluid or electrolyte replacement or abnormal distribution issues?
Look for existing deficits or excesses, ongoing abnormal losses, abnormal distribution or other complex issues.

Yes

Algorithm 4: Replacement and Redistribution

Existing fluid or electrolyte deficits or excesses
Check for:
- dehydration
- fluid overload
- hyperkalaemia/ hypokalaemia

Estimate deficits or excesses.

Ongoing abnormal fluid or electrolyte losses
Check ongoing losses and estimate amounts. Check for:
- vomiting and NG tube loss
- biliary drainage loss
- high/low volume ileal stoma loss
- diarrhoea/excess colostomy loss
- ongoing blood loss, e.g. melaena
- sweating/fever/dehydration
- pancreatic/jejunal fistula/stoma loss
- urinary loss, e.g. post AKI polyuria.

Redistribution and other complex issues
Check for:
- gross oedema
- severe sepsis
- hypernatraemia/ hyponatraemia
- renal, liver and/or cardiac impairment.
- post-operative fluid retention and redistribution
- malnourished and refeeding issues

Seek expert help if necessary and estimate requirements.

No

Algorithm 3: Routine Maintenance

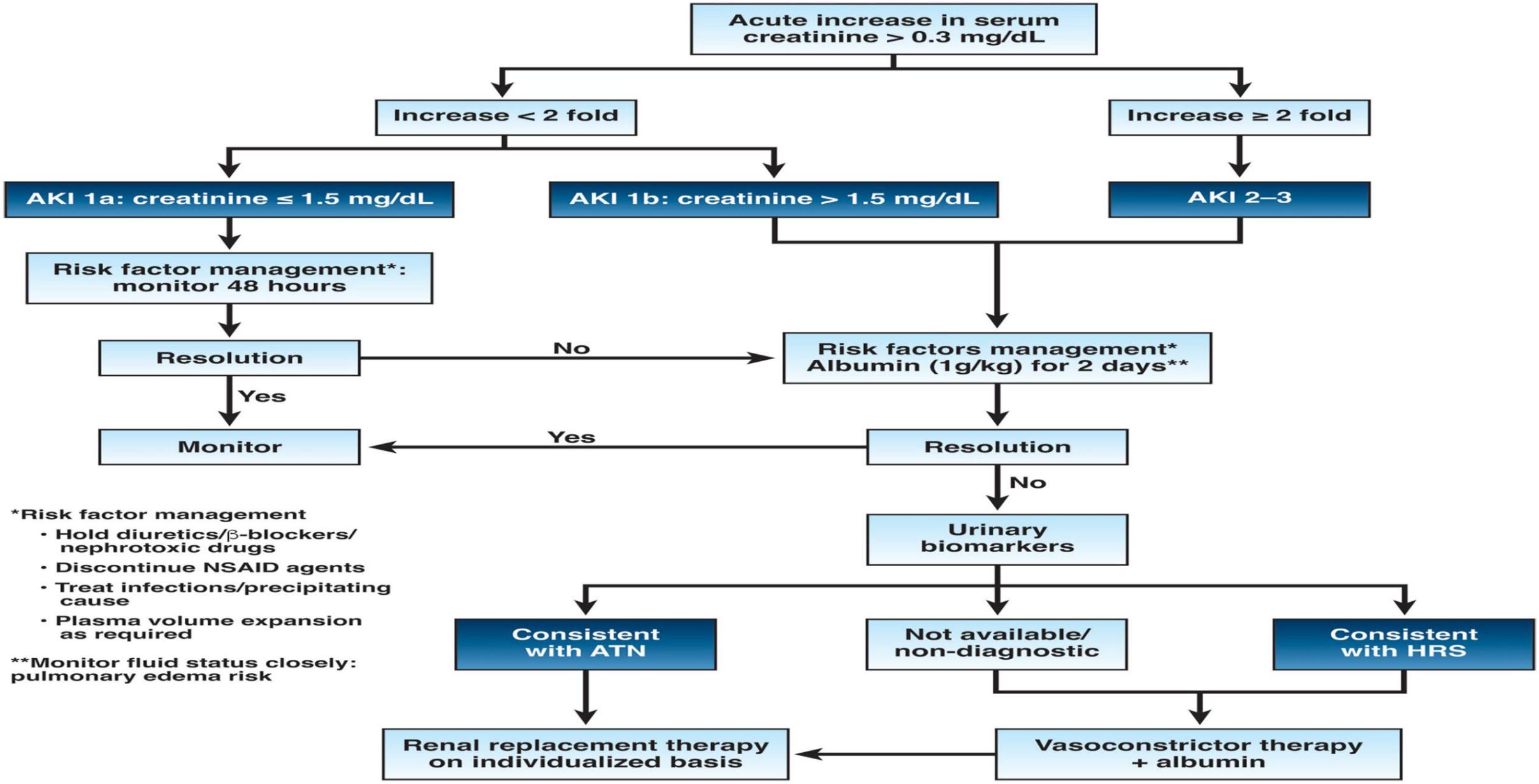
Give maintenance IV fluids
Normal daily fluid and electrolyte requirements:
- 25–30 ml/kg/d water
- 1 mmol/kg/day sodium, potassium, chloride
- 50–100 g/day glucose (e.g. glucose 5% contains 5 g/100ml).

Reassess and monitor the patient
Stop IV fluids when no longer needed.
Nasogastric fluids or enteral feeding are preferable when maintenance needs are more than 3 days.

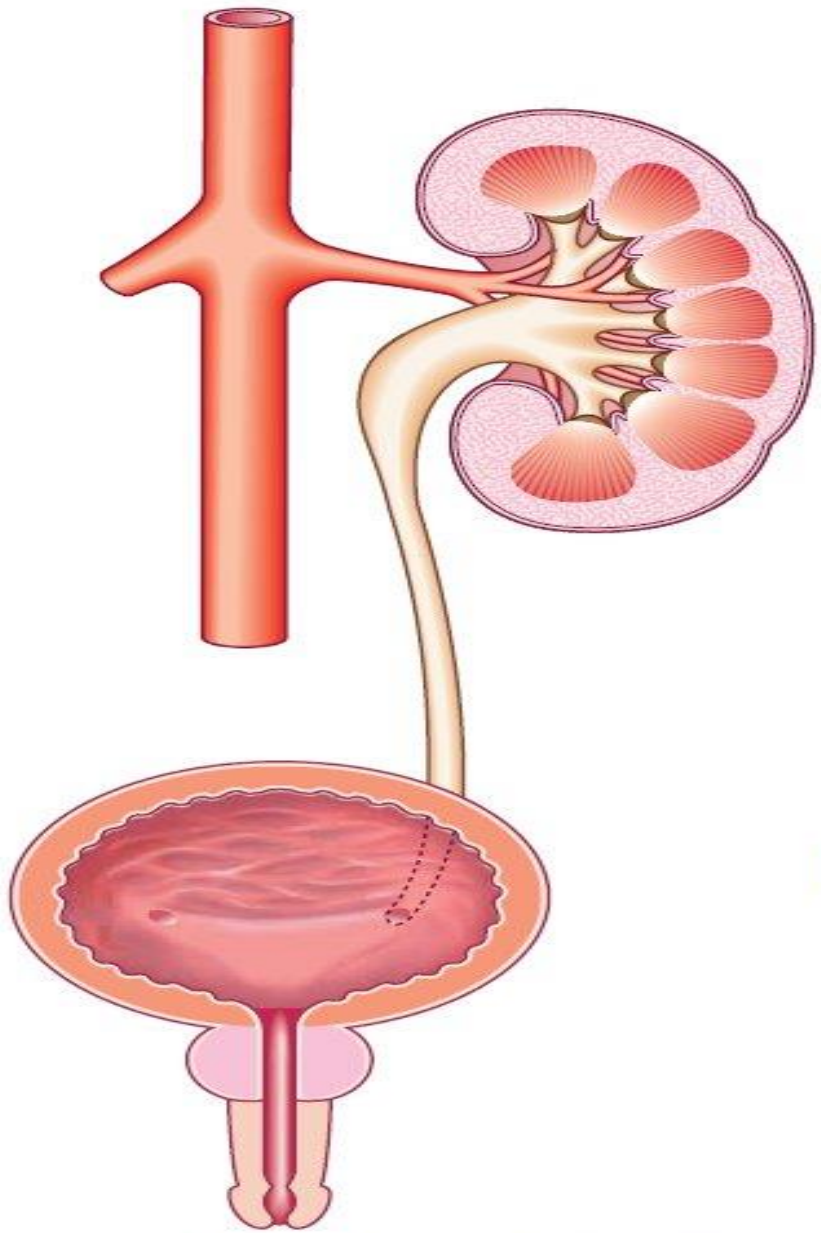
Prescribe by adding to or subtracting from routine maintenance, adjusting for all other sources of fluid and electrolytes (oral, enteral and drug prescriptions)

Monitor and reassess fluid and biochemical status by clinical and laboratory monitoring

Take Home Massage



Summary



Causes of acute kidney injury.

PRE-RENAL

Impaired perfusion:
- Cardiac failure
- Sepsis
- Blood loss
- Dehydration
- Vascular occlusion

RENAL

Glomerulonephritis
Small-vessel vasculitis
Acute tubular necrosis
- Drugs
- Toxins
- Prolonged hypotension

Interstitial nephritis
- Drugs
- Toxins
- Inflammatory disease
- Infection

POST-RENAL

Urinary calculi
Retroperitoneal fibrosis
Benign prostatic enlargement
Prostate cancer
Cervical cancer
Urethral stricture/valves
Meatal stenosis/phimosis

Final Message

No reliable evidence:

- **Dopamine and its analogues**
- **Diuretics**
- **Calcium channel blockers**
- **(ACE) inhibitors**
- **N-acetylcysteine [111]**
- **Atrial natriuretic peptide (ANP)**
- **Sodium bicarbonate**
- **Antioxidants**
- **Erythropoietin (EPO)**
- **Specific hydration fluids**

Final Message

General rules:

- Identification of high-risk patients (**biomarkers&US**).
- Discontinuation and/or avoidance of **nephrotoxins**.
- Optimization of hemodynamic and **volume** status.
- Maintenance of **euglycemia**.
- **less invasive** surgeries.
- **Goal directed fluid therapy**, not restrictive nor liberal.
- Vasopressor support (**MAP>65mmHg**).
- Restrictive threshold for blood cell transfusion(**7.5vs9.5gm/dl**).

Thank you